DESIGN OF AIRCRAFT

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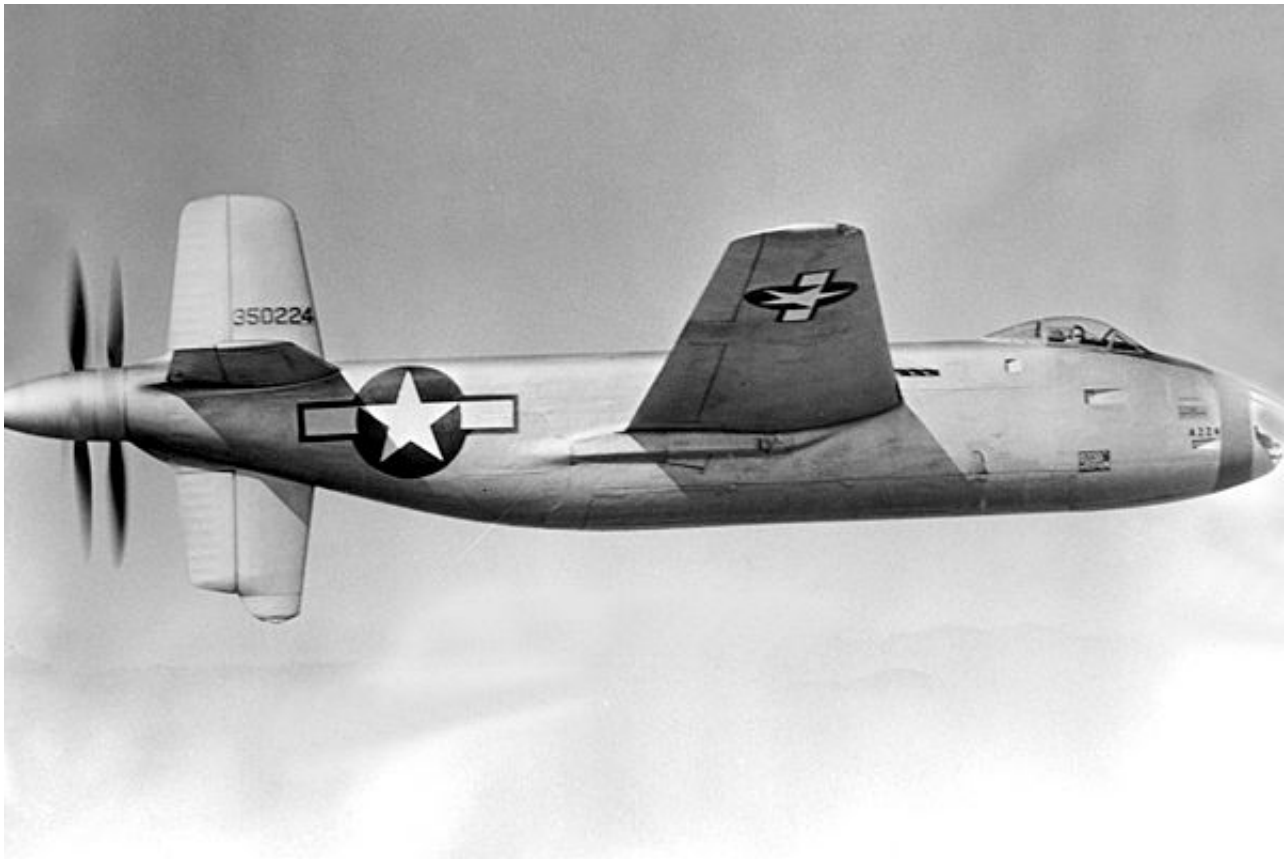
- Apparent common features to aircraft.
- Some subtle and not so subtle differences.
- Why? What motivated these?
- Reasons are the essence of aircraft design.

Fairchild Republic YA-10A

Mission:

- Ground strike and close air support aircraft
- 30mm Gatling Gun $\longrightarrow$ 20,000 lb. recoil



Douglas XB-42

Mission:

- Top Security

Grumman X-29

Mission:

- High maneuverability

Douglas YC-15

Mission:

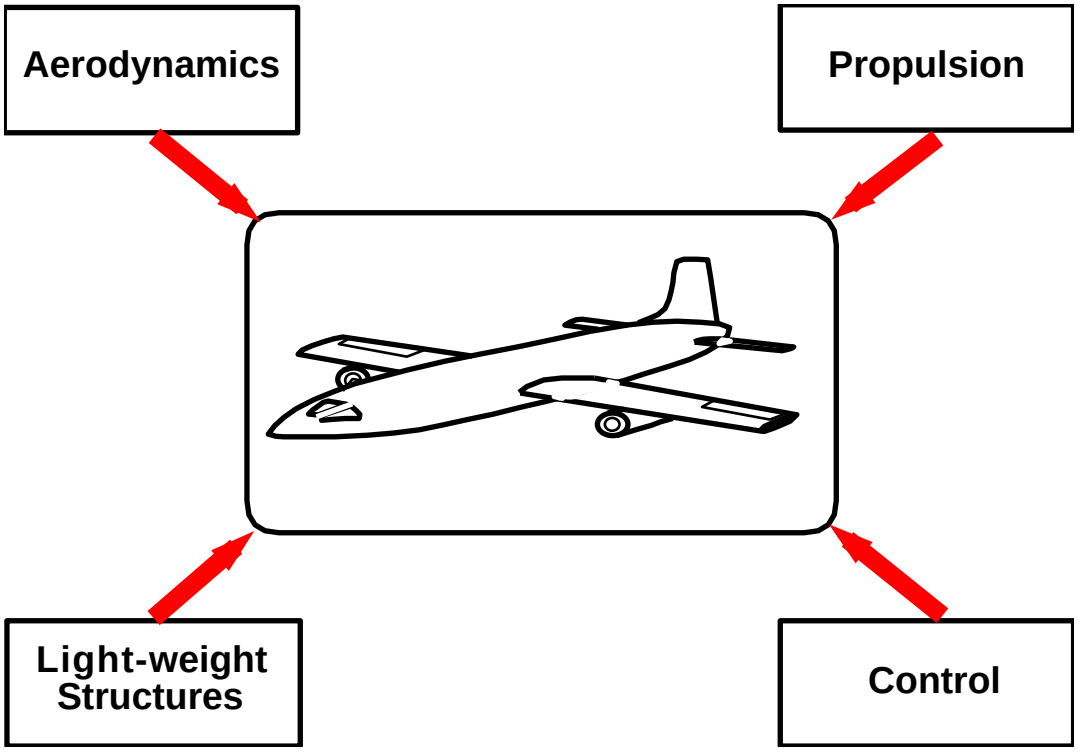
- Short Take-Off and Landing (STOL) transport

Northrop TACIT BLUE

Mission:

- Stealth

Defining a New Design



- Optimums?
- Not in everything.
- Pick IMPORTANT Design Drivers.

Consider Aspect Ratio: $A = b^2/S$

Main wing aspect ratio for different aircraft types.

Aircraft Type	Aspect Ratio
Personal	5.0 - 8.0
Commuter	9.0 - 12.0
Regional Turboprops	11.0 - 12.8
Business Jets	5.0 - 8.8
Jet Transports	7.0 - 9.5
Military Fighter/Attack	2.4 - 5.0

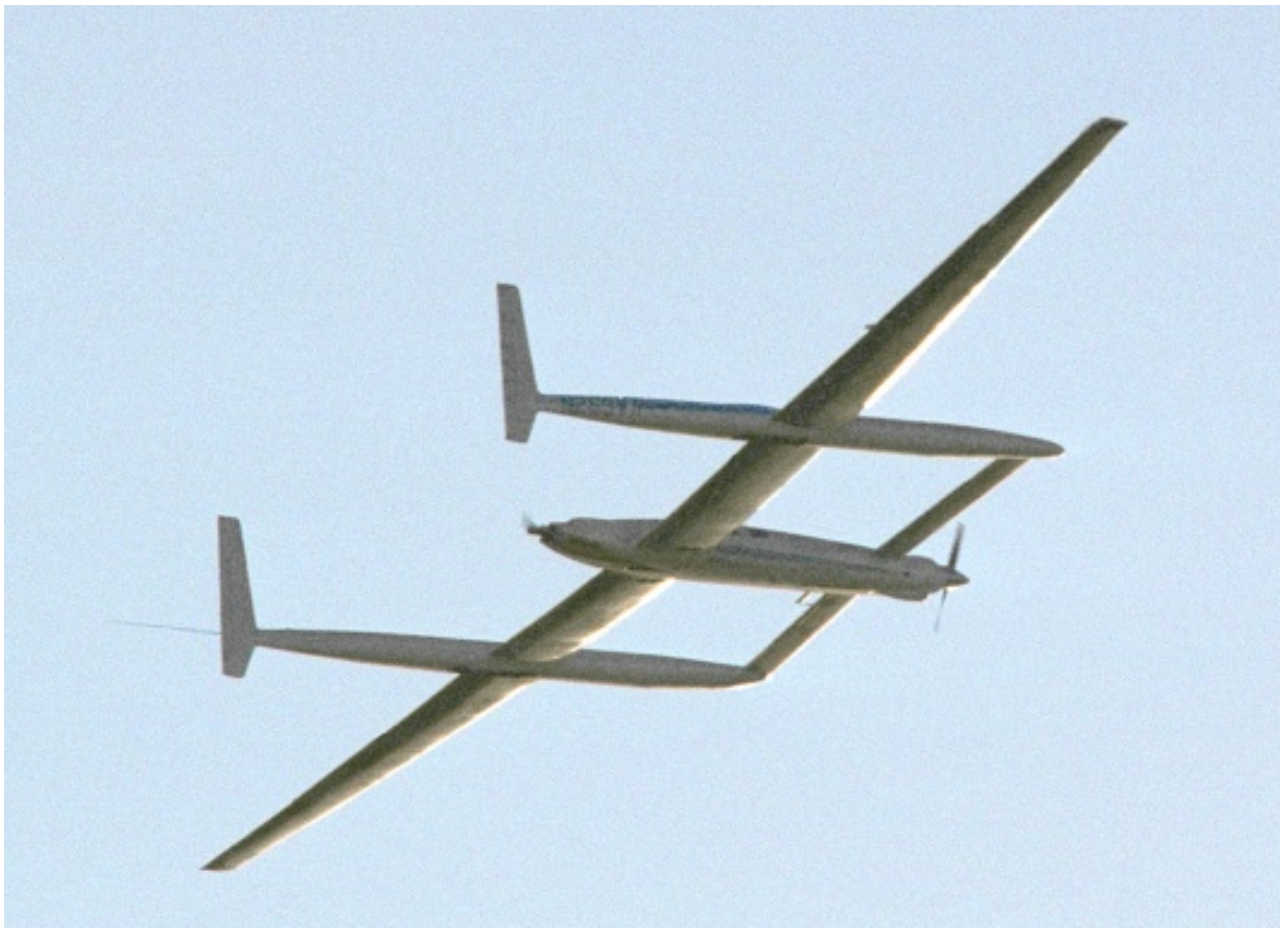
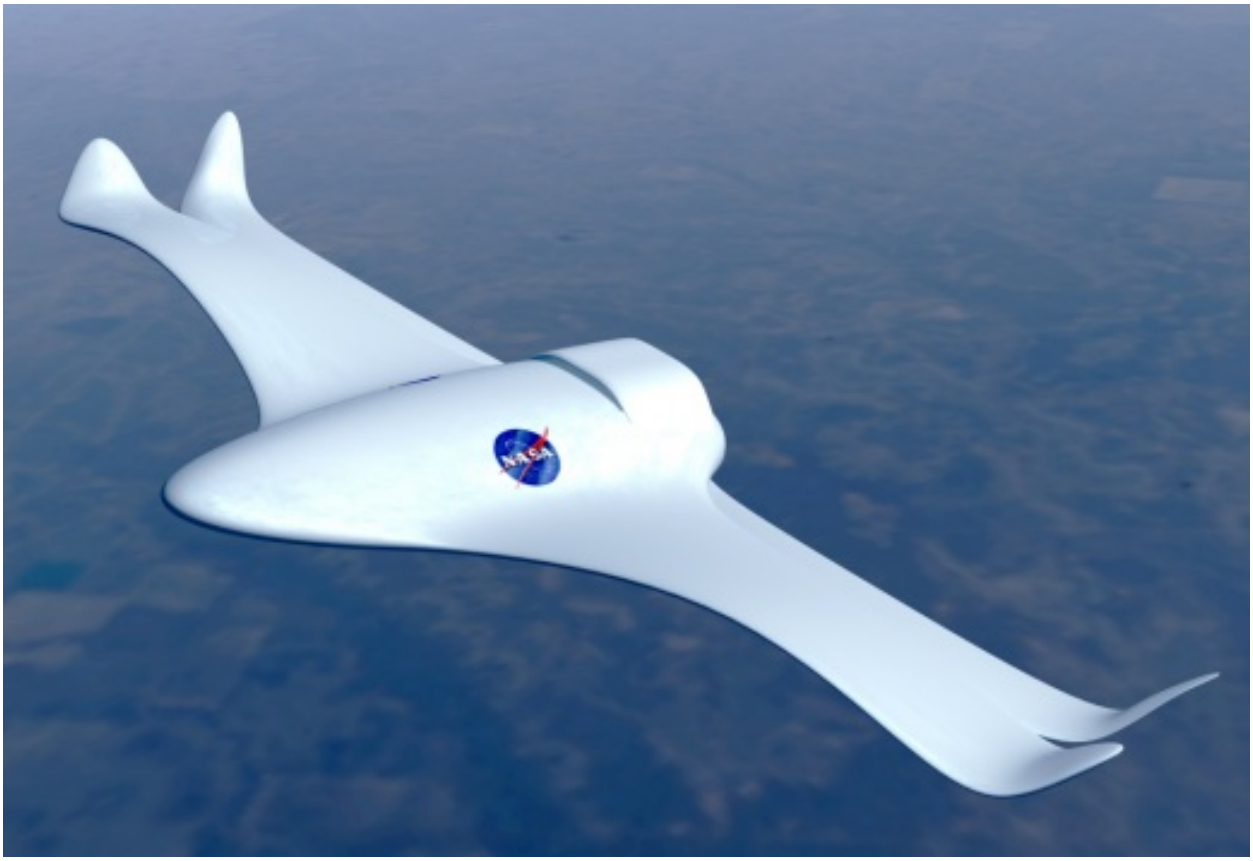


Figure 1: Photograph of the Voyager aircraft on its return from non-stop flight around the world (from the NASA Dryden photo collection).



"Morphing Aircraft"

Mission requirements:

- the aircraft purpose or mission profile,
- the type(s) and amount of payload,
- the cruise and maximum speeds,
- the normal cruise altitude,
- the range or radius with normal payload,
- the endurance,
- the takeoff distance at the maximum weight,
- the landing distance with 50% of the maximum fuel weight,
- the purchase cost, and
- other requirements considered important.

Aircraft Purpose:

- Why build it?

B-777 aircraft market gap.

type	B-767-200ER	**B-777-200**	B-747-400
passengers	181 - 224	**305 - 328**	416 - 524
range (mi)	6115 - 6615	**5925 - 8861**	8400

Payload:

- What kind? How much?

Cruise and Maximum Speeds:

- How fast? Subsonic/Supersonic

Normal Cruise Altitude:

- How high? Best altitude.

Range

- How far? Where do you want to go?.

Typical range for different types of aircraft.

Aircraft Type	Range (nautical miles)
personal/utility	500 - 1000
regional turboprop	800 - 1200
business jets	1500 - 1800
smaller jet transports	2500 - 3500
larger jet transports	6500 - 7200

Endurance

- How long do you want to fly in one place?

Takeoff Distance

- What runways do you need?

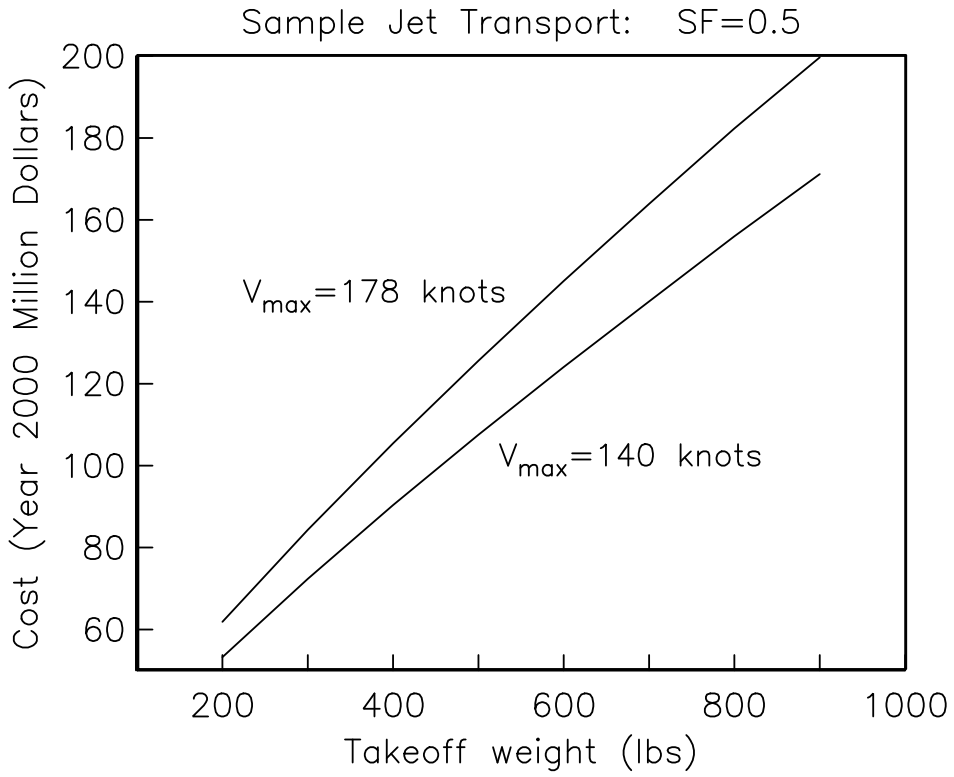
Landing Distance

- Worst case.

Purchase Cost

- How much?.

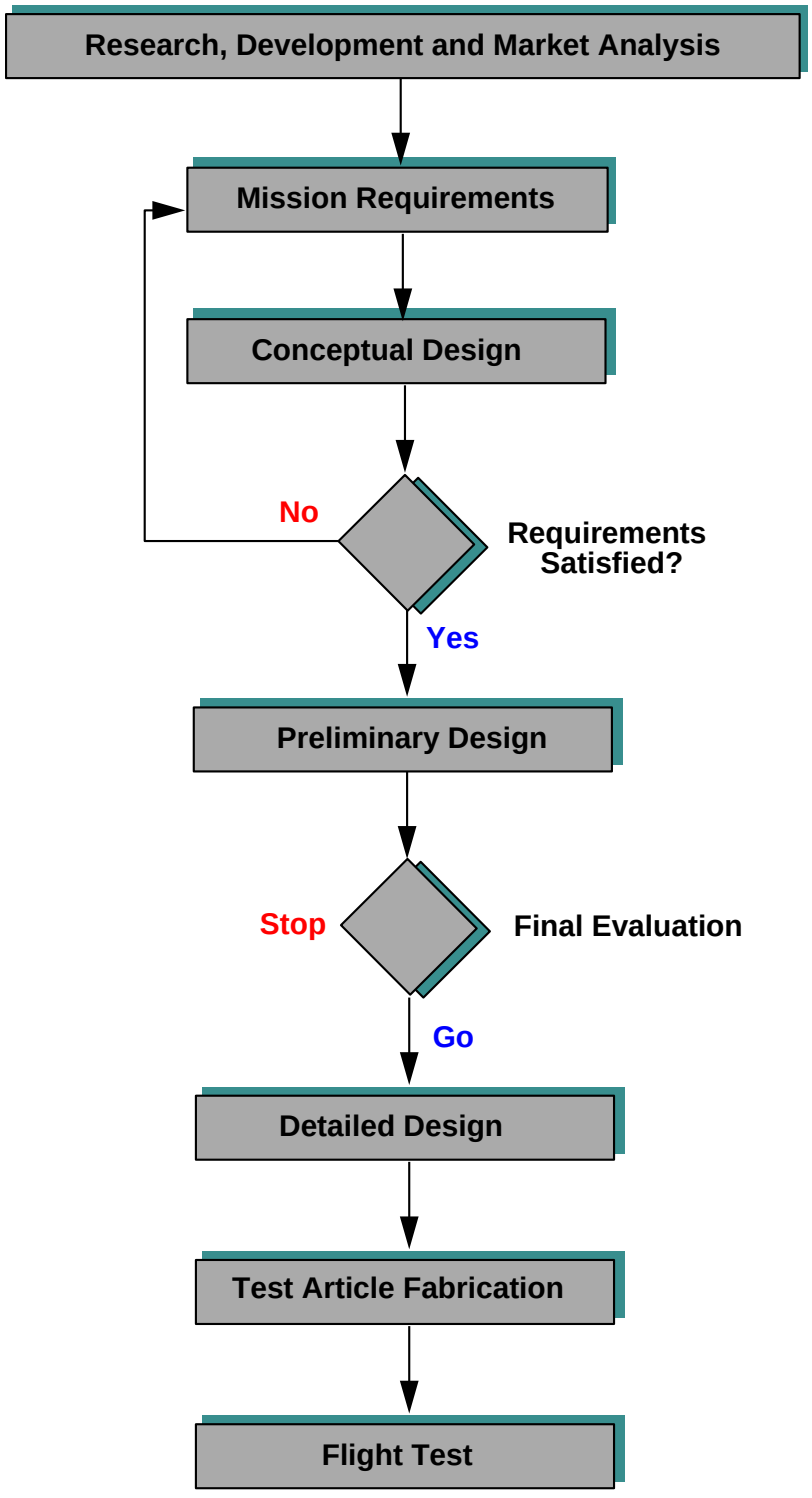
"Cost Estimating Relationships" CERs



Federal Aviation Regulations

- Airworthiness Standards. Based on aircraft categories.

Design Process



Design Proposal: Supersonic Business Jet (SSBJ).

What: We propose to design a supersonic mid-long range business jet. It is intended to have a cruise Mach number of 2.1 and a cruise altitude of 55,000 feet. Its range will be 4000nm with a full payload. Its non-expendable payload would consist of passengers and baggage, with a maximum total weight of 4000 lbs. Depending on the internal layout, this will comfortably accommodate from 12 to 15 passengers. The maximum take-off weight is estimated to be 90,000 lbs. Other features of the design include a delta wing planform, and the use of control canards. Composite materials will be used extensively to reduce the structure weight. The most critical technology readiness issue is the propulsion system. An existing engine that has been selected as a reference engine for the design is the GE-F404-100D. Based on the drag estimate at cruise conditions, the aircraft would require four of these engines.

Why: This aircraft would be the only one of its type and therefore would have no other market competitors at this time. Aircraft companies such as Boeing, Lockheed-Martin with Gulfstream, and Dassault have indicated that they are considering designs for a supersonic business jet and therefore could be potential competition.

Artists rendition of proposed Dassault design:

Drivers: The principle design drivers are a supersonic cruise Mach number, and a range and passenger number which are comparable to high-end subsonic business jets. Secondary design considerations include moderate take-off and landing distances which are comparable to existing high-subsonic business jets.

Compare: The Dassault Falcon 900B was selected as a representative subsonic business jet. It carries up to 12 passengers, and has a range of 3,840nm. To be competitive with aircraft of this class, a capability of 12-15 passengers, and a range of 4,000nm is proposed. The Sukhoi S-21 would have been the closest existing aircraft, if it had been built. It was proposed as a 6-10 passenger business jet, with a cruise Mach number of 2.0. Its proposed range was the the same as the SSBJ, and its estimated take-off weight was 106,000lbs. The proposed Dassault SSBJ has a comparable range and slightly lower Mach number. It is also intended to use three engines. The other two comparison aircraft, the Mig-31 and the Tu-22M, are each supersonic bombers. These were used for comparison because of their comparable Mach numbers.

SBJ and Aircraft with Similar Characteristics

	SSSJ	Sukhoi* S-21	Mig-31	Tu-22M	Dassault Falcon 900B	Dassault+ SSBJ
W_{T-O} (lbs)	90,000	106,000	90,000	273,000	45,500	-
M_{cruise}	2.1	2	2.8	1.9	0.87	1.8
Range (nm)	4000	4000	-	-	3,840	4000
Passengers	12-15	6-10	-	-	12	-

* note: Proposed design never built.

+ note: Proposed design.

Conceptual Design: 13 Steps.

1. Preliminary Estimate of Take-off Weight
2. Wing Loading Selection
3. Main Wing Design
4. Fuselage Design
5. Horizontal and Vertical Tail Design
6. Engine Selection
7. Take-off and Landing
8. Enhanced Lift Design
9. Structure Design and Material Selection
10. Refined Weight Analysis
11. Static Stability and Control
12. Cost Estimate
13. Design Summary and Trade Study